

## TITLE OF THE INVENTION

### **COMMUNICATION MONITORING IN A MOBILE RADIO NETWORK**

#### 5 BACKGROUND OF THE INVENTION

The present invention relates to monitoring of communications networks, and more particularly to communication monitoring in a mobile radio network.

10 In a mobile radio network data is transferred in the form of data packets or Packet Data Units (PDUs). The data transmitted includes both useful data and signaling data. Each mobile radio subscriber is allocated to a radio access entity that can exchange data with the subscriber via radio. The allocation may change with the movement of the subscriber. Each radio access entity is connected to a serving switching entity via a first link. Each  
15 serving switching entity exchanges data between plural radio access entities allocated to it or with a higher instance to which plural serving switching entities are allocated. Each serving switching entity is connected to a subscriber data base entity via a second link. The subscriber data base entity contains subscriber-oriented data of the subscriber allocated to it. The data  
20 exchanged between one radio access entity and its serving switching entity is ciphered data. First and second ciphering parameters are used for ciphering the first link. The first ciphering parameter is provided by the subscriber data base entity. The second ciphering parameter is recovered dynamically from the data exchange between such radio access entity and its serving switching  
25 entity.

Under a General Packet Radio Service (GPRS) standard the serving switching entity is a Serving GPRS Support Node (SGSN), the first link is a Gb interface, the second link is a Gr interface, the radio access entity is a Base Station Subsystem (BSS), and the subscriber data base entity is a Home Location Register (HLR).

Currently a stand-alone instrument, such as the Tektronix K1205 Protocol Tester manufactured by Tektronix Berlin GmbH, operates as a probe connected to a line, with deciphering taking place within a specific monitoring application of the instrument. All required Gb and Gr interfaces need to be connected directly to the instrument, which may provide up to sixteen (16) connections. No cooperation and especially no exchange of deciphering parameters with other instruments is possible. Any processing following deciphering, such as compiling statistics and call traces, is done directly within the instrument. However off-line processing, i.e., non-realtime processing, may be done on recorded files. Therefore, while the instrument may be used for monitoring the communication of selected links, generally it does not allow any real-time monitoring of an SGSN or of a complete mobile radio network.

Even if several instruments are used, they are not suited for cooperation with other instruments. If the instrument were expanded to a random number of connections, this only allows monitoring at fixed position, such as at an SGSN. If the data from individual instruments were collected, especially in a ciphered form for lack of ciphering parameters, and were forwarded to some central processing location, this no longer allows for real-

time monitoring. Monitoring becomes virtually impossible when a mobile radio subscriber moves from the service area of a first SGSN into the service area of a second SGSN. In this case to get the correct deciphering parameters all the connections and also the inter-SGSN connections need to be monitored.

What is desired is an improved monitoring instrument that allows the monitoring of a complete mobile radio network or any portion thereof in real-time.

## BRIEF SUMMARY OF THE INVENTION

Accordingly the present invention provides for communication monitoring in a mobile radio network by using a distributed monitoring system instead of a stand-alone instrument. One or more processing devices are coupled to different links of a serving switching entity of the mobile radio network. The processing devices extract current deciphering parameters from data on the different links, including an additional deciphering parameter set related also to the sequence number of data packets (PDUs) making up the data. The current deciphering parameters are stored in a deciphering parameter providing device so they are available for other processing devices upon request, the deciphering parameter providing device being coupled to the processing device(s) by a communication link such as a LAN or WAN. The data on the different links, if ciphered, are deciphered by the processing device and combined with delayed unciphered portions of the data to form an ordered data flow as deciphered data. A deciphered data providing device,

also coupled to the processing device(s) by the communication link, receives the deciphered data and provides it as an output for further processing. A mobile subscriber moving from one service area to another has the deciphering parameters established at set-up or renewed attach stored in the deciphering parameter providing device of one service switching entity which then provides the deciphering parameters to all the processing devices requesting them or to other deciphering parameter providing devices in adjacent service areas for availability when the mobile subscriber moves into one of the adjacent service areas using another service switching entity.

The objects, advantages and other novel features of the present invention are apparent from the following detailed description when read in conjunction with the appended claims and the attached drawing.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Fig. 1 is a block diagram view of a communication monitoring system connected to a mobile radio network according to the present invention.

Fig. 2 is a signal flow chart view for communication monitoring in a mobile radio network according to the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

For communication monitoring in a mobile radio network a distributed monitoring system is used. An intelligent distribution of functions allows a plurality of components to cooperate, which makes it possible to monitor a complete mobile radio network or any portion thereof in real time. A

deciphering architecture provides a non-intrusive monitoring system that is able to manage the deciphering process automatically. This allows a protocol analysis or procedure trace to be performed on ciphered packets.

5 The following is a description of components to be located at an SGSN, which components also cooperate with corresponding components at other SGSNs via appropriate connections, such as a Local Area Network (LAN) or a Wide Area Network (WAN). Various other constellations may be used, depending on the application purpose, of which a few are described below. It is possible to have the processing devices of plural SGSNs  
10 cooperate with a deciphering parameter providing device and a deciphered data providing device. Likewise the processing devices of an SGSN may transfer their deciphering parameters or deciphered data not only to the deciphering parameter providing device allocated to the corresponding SGSN and to the deciphered data providing device, but also to a predeterminable  
15 number of neighboring SGSNs into whose service area a mobile radio subscriber may move when changing position.

The processing device is coupled to the deciphering parameter providing device and deciphered data providing device, preferably via LAN or WAN. Especially in GPRS applications the data on first links also is ciphered  
20 by means of a third ciphering parameter besides the first two. The first two sets of parameters, obtained from the subscriber data base entity and from the flow of data exchanged between the radio access entity and serving switching entity, are normally queried by the processing device to the deciphering parameter providing device. The third ciphering parameter is a

set of parameters obtained directly from each data packet. The processing device determines the third ciphering and uses it for deciphering the data transferred on the first link. Each processing device includes a device for delaying the forwarding of selected data packets in such a manner that an  
5 ordered data flow of data packets is maintained at the output of the processing device, regardless of whether or not a data packet has been ciphered. A ciphered data flow thus enters the processing device and exits later in deciphered form while allowing the original order to be maintained. This is useful in view of the vast number of possible post-processing  
10 procedures and evaluations. Filter functions may be implemented in the processing device for application to the data flow of ciphered and deciphered data packets.

For real-time applications each processing device has a first memory, such as a cache, in which the deciphering parameters provided by the  
15 deciphering parameter providing device are stored. This avoids repeated queries for the current deciphering parameters to the deciphering parameter providing device for the same mobile radio subscriber. For particularly fast access times the memory is kept small, and the oldest entries are overwritten by the most recent entries.

20 Plural processing devices may cooperate in parallel with allocated deciphering parameter providing devices and allocated deciphered data providing devices, the number of the processing devices being chosen to cover all first and second links allocated to a serving switching entity. One example is plural processing devices, one deciphering parameter providing

device and one deciphered data providing device cooperating for one serving switching entity. Subdividing the monitoring apparatus into units per serving switching entity allows a well-arranged and clear configuration, and thus a simple structure. The processing devices are located with the SGSNs, the deciphering parameter providing device is located centrally between plural SGSNs for which it is responsible, and the deciphered data providing device is located near devices which may be used for further processing of the deciphered data flow.

The processing device first checks whether or not an incoming data packet is ciphered. If the data packet is not ciphered, the data packet is time delayed for combination with as yet ciphered data packets once these have been deciphered to give an ordered data flow. If the data packet is ciphered, it is deciphered.

First and second ciphering parameters for a data packet are retrieved using an allocation parameter that is derived from the data packet. In GPRS systems this is the TLLI/RAI information. A ciphering/deciphering parameter may also be understood to be plural ciphering/deciphering parameters, so they are provided on a corresponding link. In GPRS the parameters Kc, IOV, OC, type of algorithm (see GSM 04.64 specification) used for ciphering are referred to as a ciphering parameter allocated to a certain mobile, i.e., as a set of parameters that is only changed after switch-on of a mobile handset or after a renewed attach or that may be dynamically upgraded with the traffic transferred by the mobile -- OC parameter. Renewed attach means that a GPRS subscriber can always be on-line, since charging only is according to

data volume. The set of parameters is transferred in an unciphered form or may be determined from the data flow, so the processing device determines the current and at least the first and second ciphering parameters from the data packets coming from the respectively connected first and/or second links, and forwards them to the allocated deciphering parameter providing device for storage as deciphering parameters. There they are available to other processing devices that thus are capable of deciphering data from mobile radio operators who have only entered their monitored service area in the course of a communication.

To prevent the processing device from having to retrieve from the deciphering parameter providing device the current deciphering parameters for mobile radio subscribers that have initiated a communication in the service area of the processing device, each processing device also stores in its memory the first and second deciphering parameters it has determined. To minimize the number of queries to an allocated deciphering parameter providing device, each processing device stores in its memory the first and second deciphering parameters retrieved from the allocated deciphering parameter providing device.

In the process of deciphering data packets, each processing device first checks whether or not the required first and second deciphering parameters may be retrieved from its memory and, only if not, retrieves the parameters from an allocated deciphering parameter providing device. The third deciphering parameter, which may be among others the sequence number of a data packet transferred, may be readily determined by the



processing device and need not be retrieved from any other device. The components of the system perform data deciphering and forwarding in real time. The processing devices may be implemented as PowerWan boards, and the deciphering parameter providing device may be a Sun UNIX server.

5           The following more detailed description uses the example of a GPRS network, but may be adapted to other network standards such as Universal Mobile Telecommunication System (UMTS). Referring now to Fig. 1 all parts of a GPRS mobile radio network are shown where there is a wireless connection between a mobile handset (MRS, Mobile Radio Subscriber) **10** and a BSS **20a**. The BSS **20a** is coupled to an SGSN **12** via a Gb interface **22a**. The SGSN **12** in turn is coupled to an HLR **14** via a Gr interface **24**. The SGSN **12** also is coupled to other SGSNs, such as SSGN **16**. Via a Gn interface **25** the SGSN **12** also is coupled to a superior Gateway GPRS Service Node (GGSN) **18**. By changing position the MRS **10** enters the service area of different BSSs, as indicated by arrows, moving from the service area of BSS **20a** into the service area of BSS **20b**, and then into the service area of BSS **20c**. BSSs **20b** and **20c** are coupled to SGSN **12** via Gb interfaces **22b**, **22c**. The connections between SGSN **12** and each BSS **20a-20c** are referred to as first links **26a-26c**. The connection between the SGSN **12** and the HLR **14** is termed a second link **28**.

20           After switching on the MRS **10** or after a renewed attach, plural ciphering parameters are retrieved from the HLR **14** and part of them are transferred to the MRS **10** via the SGSN **12**. For GPRS these are the parameters Kc (ciphering key) and random parameter RAND. Other

parameters involved are obtained from the flow of data on the first link: the IOV (input offset value) that is a random value generated by the SGSN and transferred to the MRS **10**; the type of algorithm transferred to the MRS by the SGSN; and the OC (offset counter) that depends on the sequence  
5 number of the transferred or received packets – it's an offset different per direction and per transmission type based on the number of LLC (logical link control) window exceeding. Further details may be obtained from GSM 04.64 specification. A further ciphering parameter is determined between the SGSN **12** and MRS **10** from each Logical Link Control (LLC) PDU data, such  
10 as the ordering number of each LLC packet or the direction of the packet. These ciphering parameters are used for ciphering the data packets transferred on the first links **26a-26c**. Both the first ciphering parameters – provided by the HLR **14** – and the second ciphering parameters -- recovered from the LLC flow of data – are changed dynamically during the  
15 communication.

A deciphering device **30** has three different types of components – one or more processing device(s) **32a-32b**, a deciphering server **34** and an application server **36**. The different components **32-36** need not all be at the same location, but may be disposed at random sites. For example, different  
20 processing devices **32a-32b** may be located at the site of different SGSNs **12, 16**. Intercommunication between the processing devices **32** and the deciphering and application servers **34, 36**, as indicated by arrows, is preferably via LAN or WAN. As indicated by arrow **38** the deciphering server **34** may be connected to deciphering servers of other deciphering devices to

have access to deciphering parameters stored there. As indicated by arrow **40** the data of the application server **36** may be provided to a further processing device **42**. As many processing devices **32** as are required for connecting to all Gb interfaces **22** as well as all Gr interfaces **24** of the SGSN **12** may be located at the same location as the SGSN.

The components **32-36** are described in more detail with reference to the signal flow graph of Fig. 2. Starting at step **100** a Packet Data Unit (PDU) is input via the Gb or Gr interfaces **22, 24** connected to the processing device **32** and decoded in step **110**. In step **120** the PDU also is checked to determine whether ciphering parameters are present. This is possible where the PDU is part of a connection set-up or of a renewed attach. If ciphering parameters are present, the parameters are forwarded as deciphering parameters to the deciphering server **34** in step **125** and stored in memory **44** of the processing device **32**. Subsequently in step **130** the deciphering unit **46** associated with the processing device **32** checks whether or not the PDU is ciphered. If the PDU is not ciphered, it is delayed in a delaying device **48** of the processing device **32** in step **140** for combination with deciphered PDUs later on to give an ordered data flow again. If the PDU is found to be ciphered, a keyword is determined in step **150**, i.e., the TLLI/RAI information, in order to query the memory **44** in step **160** for deciphering parameters. If deciphering parameters are detected in step **170**, they are used in step **180** for deciphering the PDU, such as by means of European Telecommunication Standard Institute (ETSI) deciphering algorithms, if necessary together with further deciphering information such as the PDU sequence number. If the

deciphering parameters are not found in memory **44** in step **170**, the allocated deciphering server **34** is queried in step **190**. In step **200** the deciphering parameters are loaded into the deciphering unit **46** and in step **210** the memory **44** is updated to avoid repeated access to the deciphering server **34**.

5 In step **220** the PDUs transferred in an unciphered form and the deciphered PDUs are combined to give a data flow and transferred to the application server **36**. Whether further PDUs are present on the inputs of the processing device **32** is checked in step **230**. If so, the process returns to step **110**, otherwise the process is terminated at step **240**.

10 Additional embodiments and modifications are within the scope of the invention. For example the deciphering parameters in the deciphering server **34** may be deleted once a subscriber has terminated the connection in order to minimize the time spent searching for deciphering parameters of other subscribers.